

UNCLASSIFIED

AD NUMBER

AD313258

CLASSIFICATION CHANGES

TO: unclassified

FROM: secret

LIMITATION CHANGES

TO:

Approved for public release, distribution unlimited

FROM:

Distribution authorized to U.S. Gov't. agencies only; Specific authority; 30 July 1959. Other requests shall be referred to Diamond Ordnance Fuze Labs, Washington, DC.

AUTHORITY

OCA, 26 Jun 2000; Diamond Ordnance Fuze Labs, Washington, DC.

THIS PAGE IS UNCLASSIFIED

SECRET

AD

313258

1

OF

1

NO COPY
OF THIS

Reproduced by

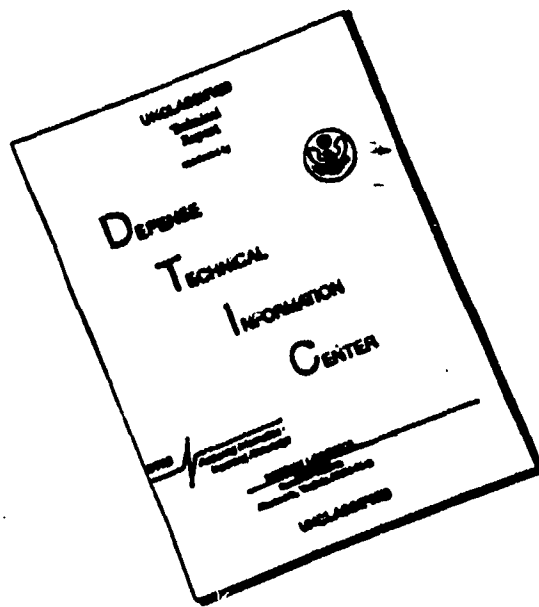
Services Technical Information Agency

ARLINGTON HALL STATION; ARLINGTON 12 VIRGINIA

SECRET

NOTICE: When Government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the U.S. Government thereby incurs no responsibility, nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

FILE COPY

RETURN TO

ASTIA

ARLINGTON HALL STATION

ARLINGTON 12, VIRGINIA

ATTN: TISS

Reproduction of this document, in whole or in part, by an agency outside the Department of Defense, is prohibited except with permission of the Diamond Ordnance Fuze Laboratories; DOKFL, ASTIA is authorized to reproduce the document for United States Government purposes. Further distribution may be made only to authorized agencies, and such additional distribution will be reported to ASTIA.

✓ Requests for copies of this document may be made to the Armed Services Technical Information Agency, Arlington Hall Station, Arlington 12, Virginia.

This document is furnished for information only and may not be released to any other nation without specific approval by the Assistant Chief of Staff for Intelligence, Department of the Army. It will be afforded the same degree of security protection as that afforded by the Department of the Army. It may not be used for other than military purposes. License to make, use or sell the subject matter of any inventions disclosed in this document is not granted, and any manufacture, use or sale of such inventions is at the risk of the recipient of this document.

When need for this document no longer exists, it should be returned to ASTIA.

This document contains information affecting the national defense of the United States within the meaning of the espionage laws, title 18, U.S.C., 793 and 794. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

SECRET

DIAMOND ORDNANCE FUZE LABORATORIES
ORDNANCE CORPS WASHINGTON 25, D. C.

DA-912-15-018
ORD Proj. T12-3051
DOFL Proj. 3A250

30 July 1959

TR-733
24 pages
Copy No. _____

CIGARETTE FUZE FIELD TEST (U)

Gerald W. Kinselman

FOR THE COMMANDER:
Approved by:

J. Rothin
J. Rothin
Chief, Laboratory 300



SECRET

TABLE OF CONTENTS

	Page
Abstract	3
1. Introduction	3
2. Conclusions	3
3. Recommendations	3
4. Summary of Firing Tests	6
5. Details of Firing Tests	6
6. Acknowledgments	8
7. References	8
APPENDIX	13

SECRET

LIST OF FIGURES

	Page
Figure 1. 81-mm test vehicle-assembled for firing	9
Figure 2. 81-mm test vehicle-exploded view	10
Figure 3. Amplifier and oscillator-exploded view	11
Figure 4. 81-mm test vehicle assembly.	12
Figure 5. Schematic diagram-amplifier A	14
Figure 6. Pot core	15
Figure 7. Output voltage vs distance from ground (Amplifier A).	17
Figure 8. Schematic diagram-amplifier B	18
Figure 9. Output voltage vs input voltage (Amplifiers A and B).	19
Figure 10. Output voltage vs distance from ground (Amplifier B).	20

SECRET

This document contains information affecting the national defense of the United States within the meaning of the espionage laws, Title 18 U. S. C., 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

SECRET

ABSTRACT ^C (S)

Twenty-three "Cigarette" fuses were mounted in 81-mm mortar shell and tested by field firing at two increments. The score was:

16 - proper function

3 - indeterminate

2 - early

2 - no fuse test

Function height varied from 1 to 6 inches above ground. These tests showed that Cigarette fuses are suitable for use with projectiles.

1. INTRODUCTION

The original Cigarette fuse was developed for a hand grenade. The entire fuse, including power supply and safety and arming mechanism, was fabricated in a package similar in size and shape to a king-sized cigarette. However, this fuse was not carried beyond prototype stage. Other demonstration models of this type of fuse had also been built (refs 2 and 3) prior to the test described in this report, but these models were not designed for firing.

The Cigarette fuse is an a-c capacitance fuse. The principle of operation is described in reference 1. Essentially, the fuse consists of a body with two electrodes. The capacitive coupling between the electrodes changes when the body approaches some object closely. The fuse measures the change in capacitance, and this signal is used to fire a detonator. Design details are discussed in the appendix.

The tests described herein were designed to demonstrate that Cigarette fuses could be built to survive the conditions of projectile firing and to function properly when approaching targets at projectile speeds.

2. CONCLUSIONS

The test showed that Cigarette fuses are suitable for use in projectiles.

3. RECOMMENDATIONS

Several factors should be investigated in the further development of a-c capacitance fuses. One is the possibility of eliminating neutralization of the free-space signal. Another is the effect on function height and free-space signal of the shape, position, and size of the antennas. Other forms of firing circuits should be considered, such as the use of cold-cathode thyatrons or solid-state switches.

SECRET

SECRET

To increase the signal-to noise ratio and for additional protection against interference, features such as tuned input circuit and synchronous detection can be considered. Magnetic shielding between oscillator and amplifier may not be necessary, but additional experimental work is required to determine actual shield requirements.

4. SUMMARY OF FIRING TESTS

Twenty-three rounds were fired and the following score was obtained:

18 - proper function

3 - indeterminate

2 - early

2 - no fire test

The details of the tests are summarized in table 1.

5. DETAILS OF FIRING TESTS

The test vehicle selected was the 31-mm mortar shell fired with two instruments. The M537 fuze nose cone, the final power supply, and safety and arming mechanism were used to expedite fabrication of the necessary hardware. The assembly is shown in figures 1 through 4. Holes in the side of the shell were closed with plugs intended to blow out at detonation so that the flash would be visible.

Photographic coverage was used to obtain function heights. High-speed motion pictures were taken at the time the shell approached the ground, and low-speed pictures were taken with a background scale, marked off in feet from ground, at the spot where the shell landed. When the two pictures were compared, the height of the flash above the ground was obtained. The distance from nose to flash hole was subtracted to obtain the distance between the nose and the ground at the time of the flash. Actual functioning could have been somewhat higher than the measured flash (about one inch) because of the motion between frames. Results were rounded to the next higher full inch. The function height varied from four to six inches.

Firing of the 23 rounds was begun on 5 November 1959. Of two rounds fired, the first round showed a flash near the ground, and the second showed no flash. After recovery, it was determined that the second fuze had functioned. Similar troubles at a later date are discussed below.

Three more rounds were fired on 9 January 1959. The first round flashed above ground, the second had a propellant failure and did not reach arming velocity, and the third flashed above ground.

On 23 February 1959, seven rounds were fired: four were successful and three showed no flash. Firing was then stopped until the rounds could be recovered

SECRET

SECRET

TABLE 1
ROUNDS FIRED

Date	Round- Amplifier	Tetryl	Proper Function	Function Height Inches	Remarks
11-5-58	A	No	Yes		One increment
	A	No	Yes *		One increment
1-9-59	B	No	Yes		Not Neutralized
	B	No	No		Propellant failure-- fuse did not arm
2-25-59	B	No	Yes		
	3-B	No	No		Battery circuit was open
	5-B	No	Yes	4	Blowout plugs intact
	6-B	No	Yes		
	7-B	No	Yes *		Blowout plugs intact
	8-B	No	Yes	4	
	10-B	No	Yes	3	Blowout plugs intact
	11-B	No	Yes *		Three blowout plugs intact
	12-B	Yes	Yes	4	
	13-B	Yes	Yes	6	
	14-B	Yes	Yes		
3-20-59	20-B	Yes	Yes	1	
	21-B	Yes	Yes	5	
	22-B	Yes	Yes	1	
	23-B	Yes	Yes	2	
	24-B	Yes	No		15-sec function
	25-B	Yes	Yes	2	
4-1-59	9-B	Yes	Yes		Light to moderate rain
	15-B	Yes	No		Moderate to heavy rain; 12-sec function

* Indeterminate -- no flash was observed but recovered fuse had functioned. Believed to be proper function but wrong orientation to see flash when no tetryl was used.

SECRET

SECRET

for examination. Two of the nonflashing rounds had functioned. However, on one the plugs were intact, and on the other only one plug had been blown out. It was decided that the flash powder was not sufficiently powerful to give definite indication unless the orientation of the round happened to be suitable, and that a piece of tetryl should be substituted for one of the flash powder discs in future rounds. The test vehicle had been designed and tested initially in this manner, but flash powder was substituted for the tetryl to permit recovery if necessary. The third nonflashing round had the detonator in line but the detonator had not fired. It was fired successfully in a laboratory test. However, the 6.4-volt battery was still good days after it should have been run down and the battery connection to ground was open. Hence, the amplifier had not been energized. Therefore, this round was not considered a first test. A connection between a screw and a soldering lug in the potted amplifier had not been soldered, and was believed to have opened from the shock of firing.

On 20 March 1959, nine more rounds were fired. All functioned, but one exploded in mid-air after 13 seconds. Firing was at 30° elevation and flight time was about 24 seconds.

On April 1, 1959, two more rounds were fired. The first was fired in light to moderate rain and functioned satisfactorily. The second was fired in moderate to heavy rain and functioned in mid-air after 12 seconds. The two earliest are attributed to the same unsoldered connection mentioned above. It is assumed that this connection opened from vibration during flight and removed the bias from the thyatron, thus causing the detonation.

6. ACKNOWLEDGMENTS

John J. Furlani and James Miscampbell conducted the mechanical phases of this project. Lloyd R. Crump developed the electronic circuitry. The Model Shop fabricated the electronic equipment used in the firing tests.

7. REFERENCES

- (1) H. P. Kalmus, "The Cigarette Fuze," (U); DOFL Report TR-734, Secret, 15 July 1959.
- (2) G. R. Yetter, "A Miniature Transistorized Fuze For Short Ranges--Cigarette Fuze," (C); DOFL Report R-51-57-19, Confidential, January 1959.
- (3) Zenith Radio Corporation Final Report, Secret, DOFL Contract DA-49-186-502-ORD-579, May 1958.
- (4) Lloyd R. Crump, "A Transistor Sine Wave Oscillator," DOFL Report TR-599, June 1959. (referenced in appendix)
- (5) Lloyd R. Crump, "Electronic Circuitry For Electrostatic Capacity Fuze For Mortar Firing," (U); DOFL Report R-100-29-1, Confidential, February 1959. (referenced in appendix)

SECRET

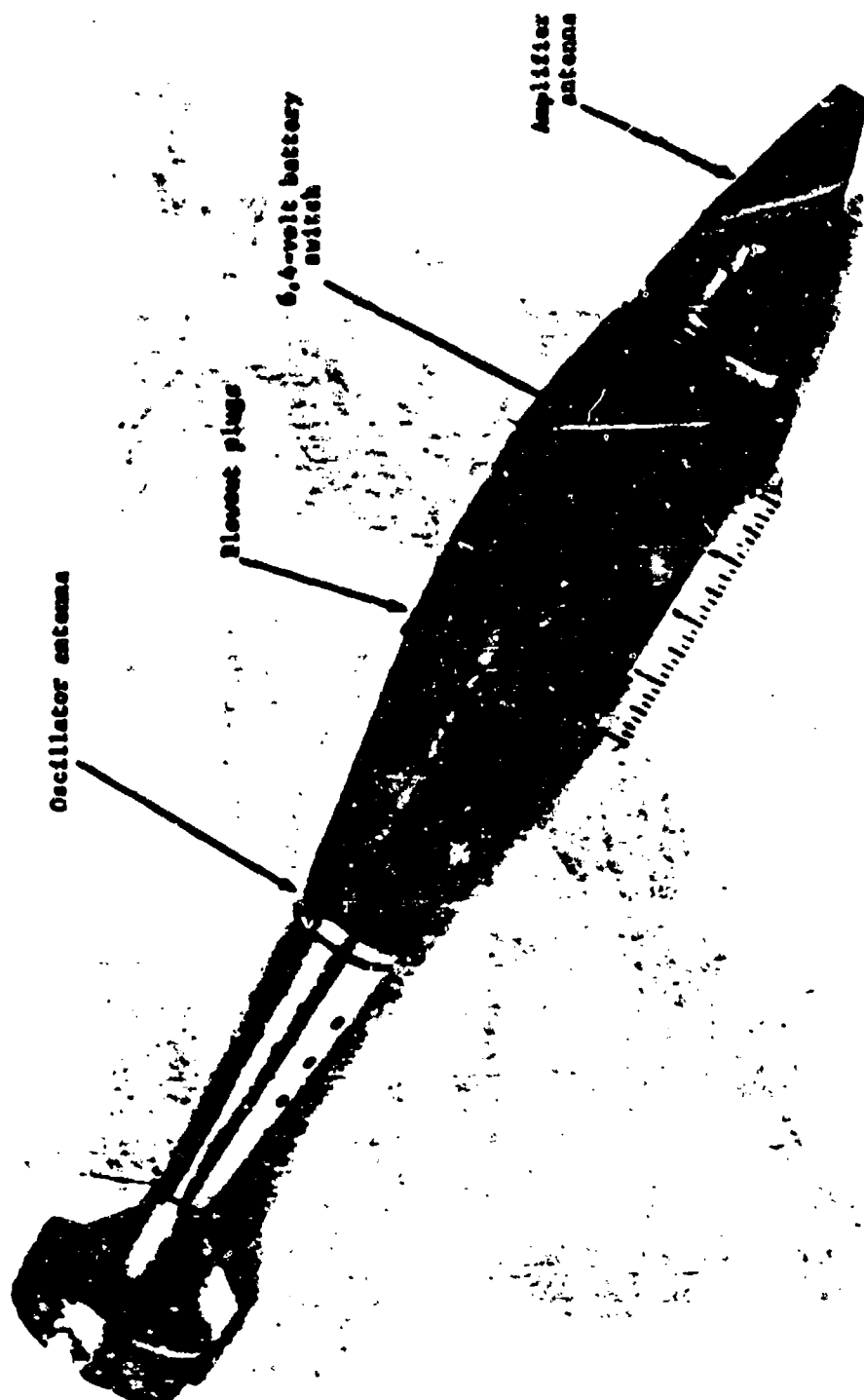


Figure 1. 61-mm test vehicle— assembled for firing.

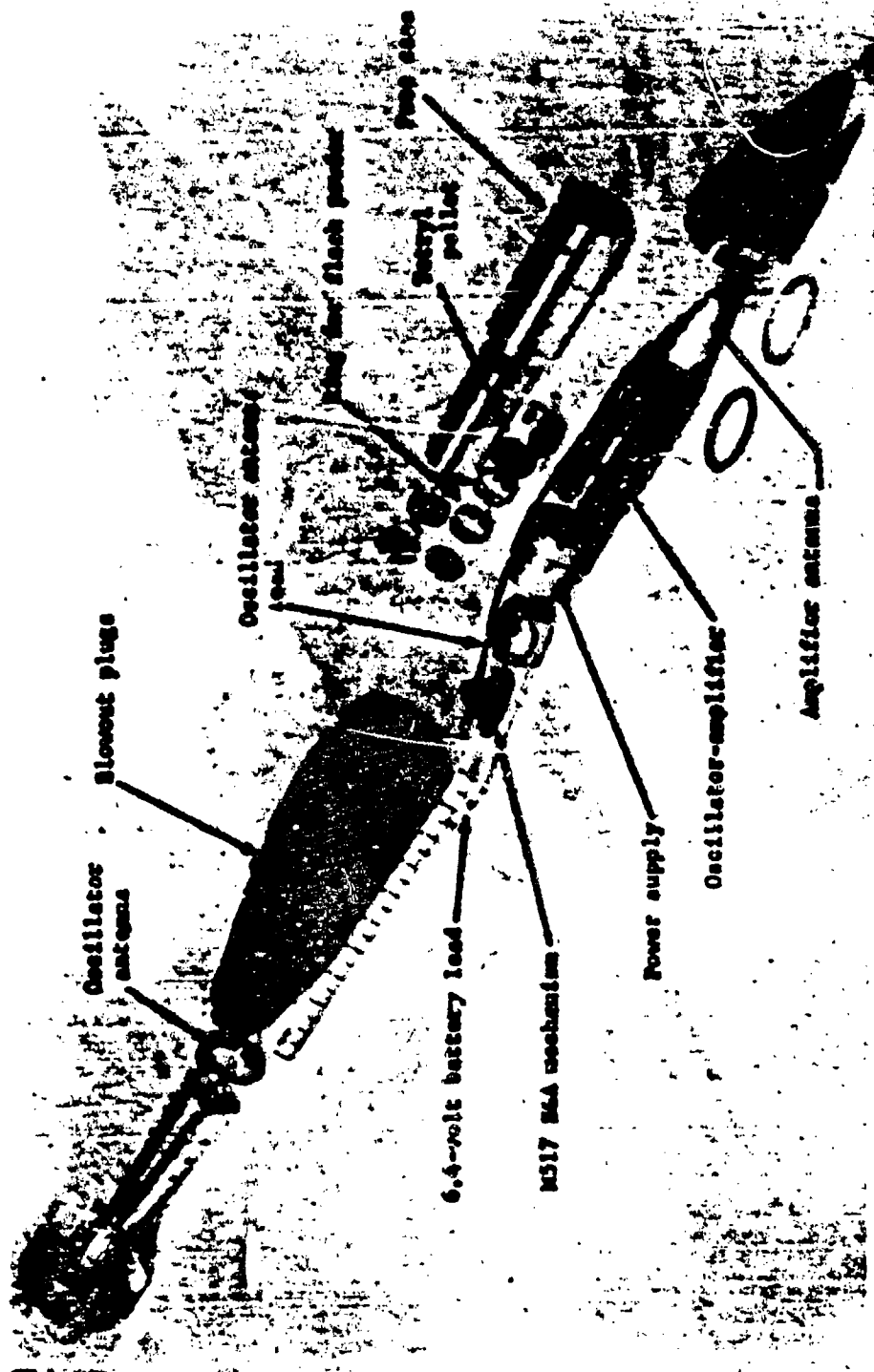


Figure 2. 81-mm test vehicle--exploded view.

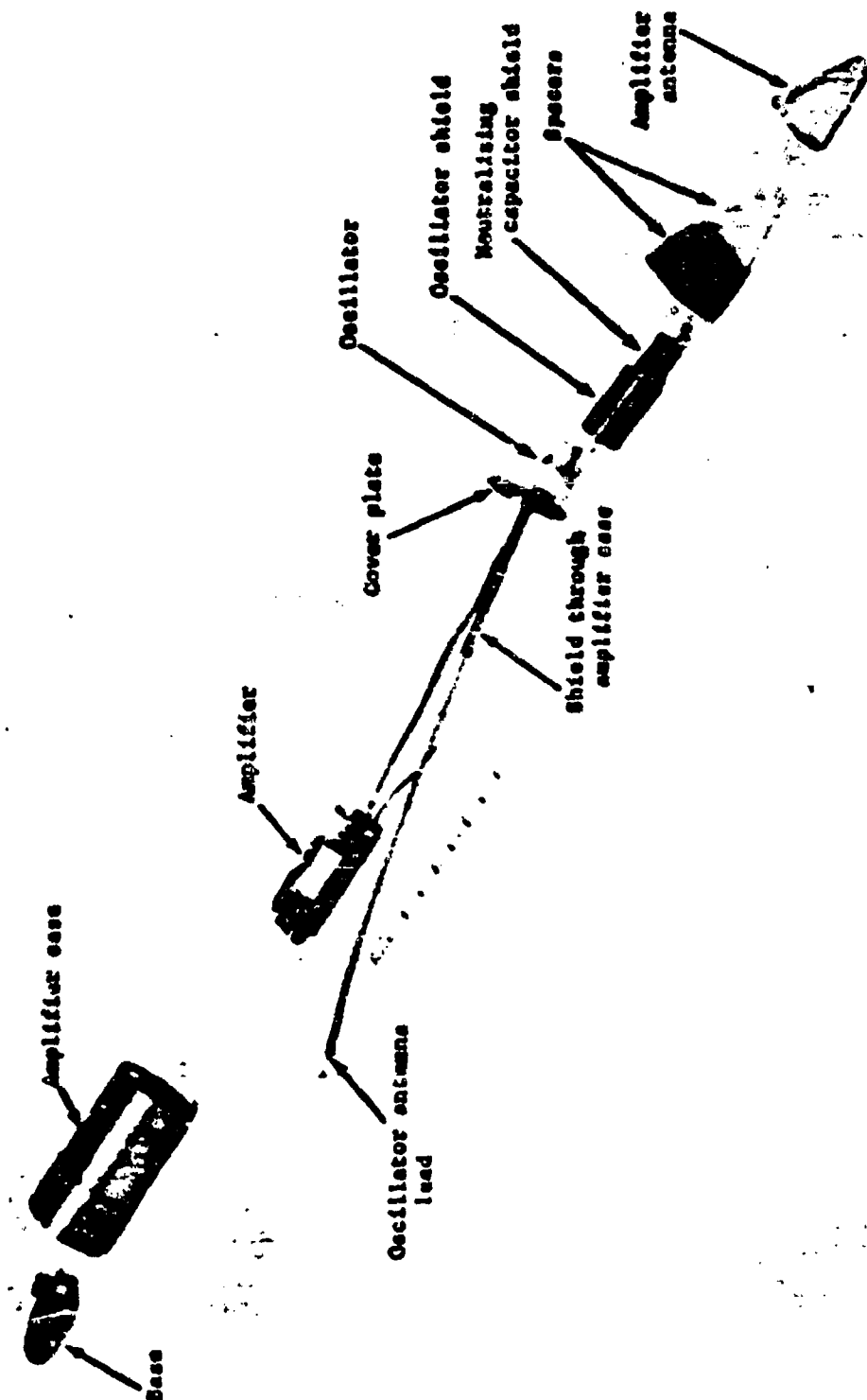
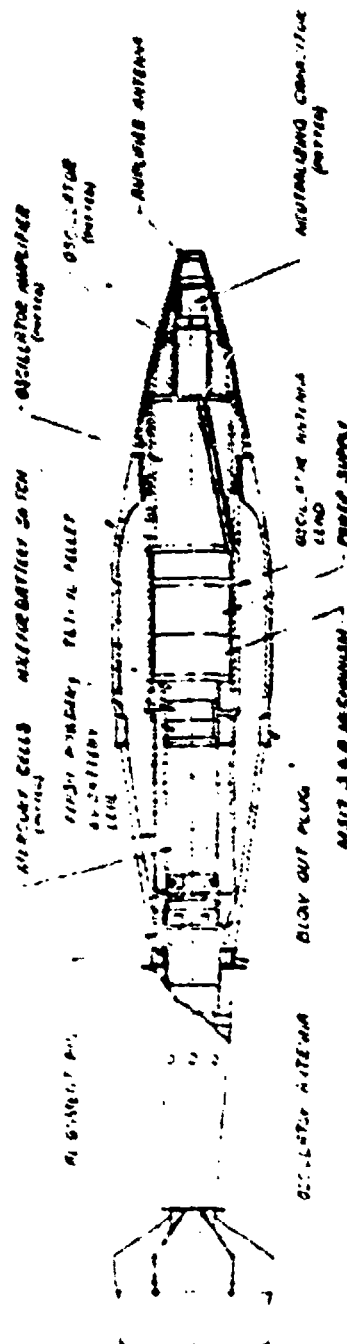


Figure 3. Amplifier and oscillator—exploded view.



SECRET

APPENDIX - Design Details

MECHANICAL FEATURES

Several configurations were considered for the electronic packages. The arrangement used was more difficult to achieve but it was selected to simulate proposed use of the fuse. In this proposed use, the oscillator and amplifier were adjacent to each other, and a long shielded lead was used on the oscillator output. This arrangement required the oscillator output lead to pass through the amplifier case. Since there was no time to determine the amount and type of shielding necessary between oscillator and amplifier, fairly heavy magnetic and electrostatic shielding was used. The nose antenna of the M517 fuse was used as the amplifier antenna. An insulated ring was inserted between the shell and the tail boom for the tail antenna.

A switch for the mercury battery (in the form of a grounding screw) was added on the later models so that assembly of the package for firing could be made without having the amplifier energized. Without the switch, the round had to be fired within two hours of assembly to insure that the battery voltage had not fallen off.

The M48 detonator was tested with an electronic breadboard simulating the proposed firing circuit of the fuse. This detonator was selected because of its short functioning time (about 5 microseconds). However, this detonator did not appear to be sufficiently reliable when used with the proposed circuit. (One dud was obtained and, when used with a tetryl lead, the dent in the test block varied from 0.030 to 0.050 inch). Then the M52 detonator, which is more sensitive and more directional in its explosive output, was tested. Its functioning time varied up to 64 microseconds when tested at 100 volts. This delay in function was considered acceptable, and the M52 detonator was selected for the field tests.

ELECTRONIC FEATURES

The oscillator was based on the circuit of reference 1. The amplifier was based on the circuit of reference 2, with output modified to use a thyratron for firing a detonator, and the bandwidth reduced for improved signal-to-noise ratio (ref 3). The firing circuit was developed to suit the application.

The oscillator was constructed in accordance with the schematic of figure 5. The first oscillator coils were wound with Ceroc wire. This wire was found to be too hard to work with because of its small size (#4) and the difficulty of stripping the insulation. Wire with insulation of the Formex-Formvar-Nyclad type was substituted, and was satisfactory; sizes 36 and 42 were used. The iron core was of the shape shown in figure 6.

These oscillators had a resonant frequency of over 40 kc. When the shielded output lead was added, the frequency dropped to about 15 kc. Therefore, amplifiers were designed to peak near 25 kc. Later, with a different lot of cores the frequency of the oscillators with leads fell as low as 13 kc. The frequency was brought up to the 25 kc region by grinding the center of the core a few thousandths of an inch below the outside face, leaving a small airspace in the center leg.

SECRET

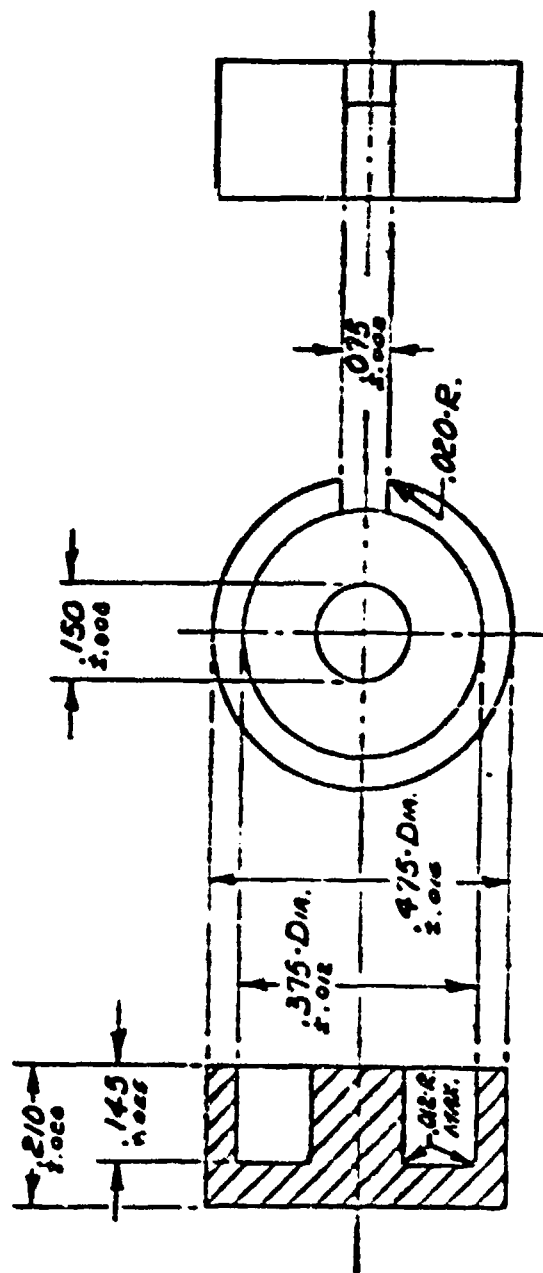


Figure 6. Pot core.

SECRET

The amplifier was also constructed in accordance with figure 5. First attempts at building the amplifier gave unsatisfactory results. Finally a working model was built by providing copper shields between the first and second stages and between the third and fourth stages. The transformer was fabricated using the core of figure 6.

The system was checked by installing it in a shell with the intended external configuration and without the neutralizing capacitor. Oscillator and amplifier were energized with batteries contained within the shell, and a d-c voltmeter with 1-meg-ohm resistance was inserted in the output circuit at the test lead. This voltmeter was also mounted within the shell. The shell was hung in the air with insulating cords. The "free space" signal input to the amplifier was observed to saturate the amplifier. The gain of the amplifier was lowered until the amplifier was not saturated, and then the voltage output was observed. Next, a low impedance signal source at the oscillator frequency was applied to the amplifier input. A 4-millivolt signal was required to give the amplifier output obtained in free space.

The original amplifier saturated at 15 volts dc with 1.5 mv rms input. The free space signal was thus approximately three times the signal range of the amplifier. Decreasing the amplifier gain would decrease the function height. For example, if the gain were decreased so that 3-mv input would give 15 volts output, the free space output would be about 10 volts, and the function height for 15-volts output would be about 1 inch.

To increase the function height it was decided to retain the full amplifier gain, and to neutralize the free space signal with a 4-mv signal. The phase of the 4-mv signal was reversed with respect to the space signal. This neutralization was provided with a tap on the oscillator and an adjustable capacitor voltage divider to feed a signal to the amplifier antenna. With use of the adjustable capacitor the free space signal could be neutralized readily to within 0.2 mv.

A shell with free space neutralization was hung on an insulating cord with nose end down, and the voltage output of the amplifier was recorded as a function of the distance from the shell to a ground plate. Typical results are shown in figure 7. The straight-line result is caused by the nonlinearity of the amplifier. A hyperbolic type of curve would result from a linear amplifier.

A differentiating network was used on the output of the amplifier so that firing of the detonator would occur on a change of signal rather than on the magnitude of the signal. The hold-off bias on the thyatron grid is -6.4 volts and the thyatron fires with a bias of about -3.0 volts. Thus a rapid 4-volt change in amplifier output is necessary to fire the round. From the curve in figure 7 it is seen that the round should fire about 4 inches above the ground. Five rounds of this type were fabricated but only two checked out suitably for firing.

At about this time it was learned that the 2N125 transistors used in the amplifier had a high failure rate when fired at 10 increments (11,000 g). Tests were conducted with these transistors to determine if they would be suitable for use at lower accelerations. Twenty transistors were fired in the 51-mm mortar with a charge of three increments (2300 g). Fifteen units were oriented so that the accelerating force was normal to the surface of the germanium wafer. Four units failed. Five units were oriented with the accelerating force parallel to the wafer, and one of these failed. To reduce the shock on the transistors, the two rounds are fired at one increment (1000 g).

SECRET

SECRET

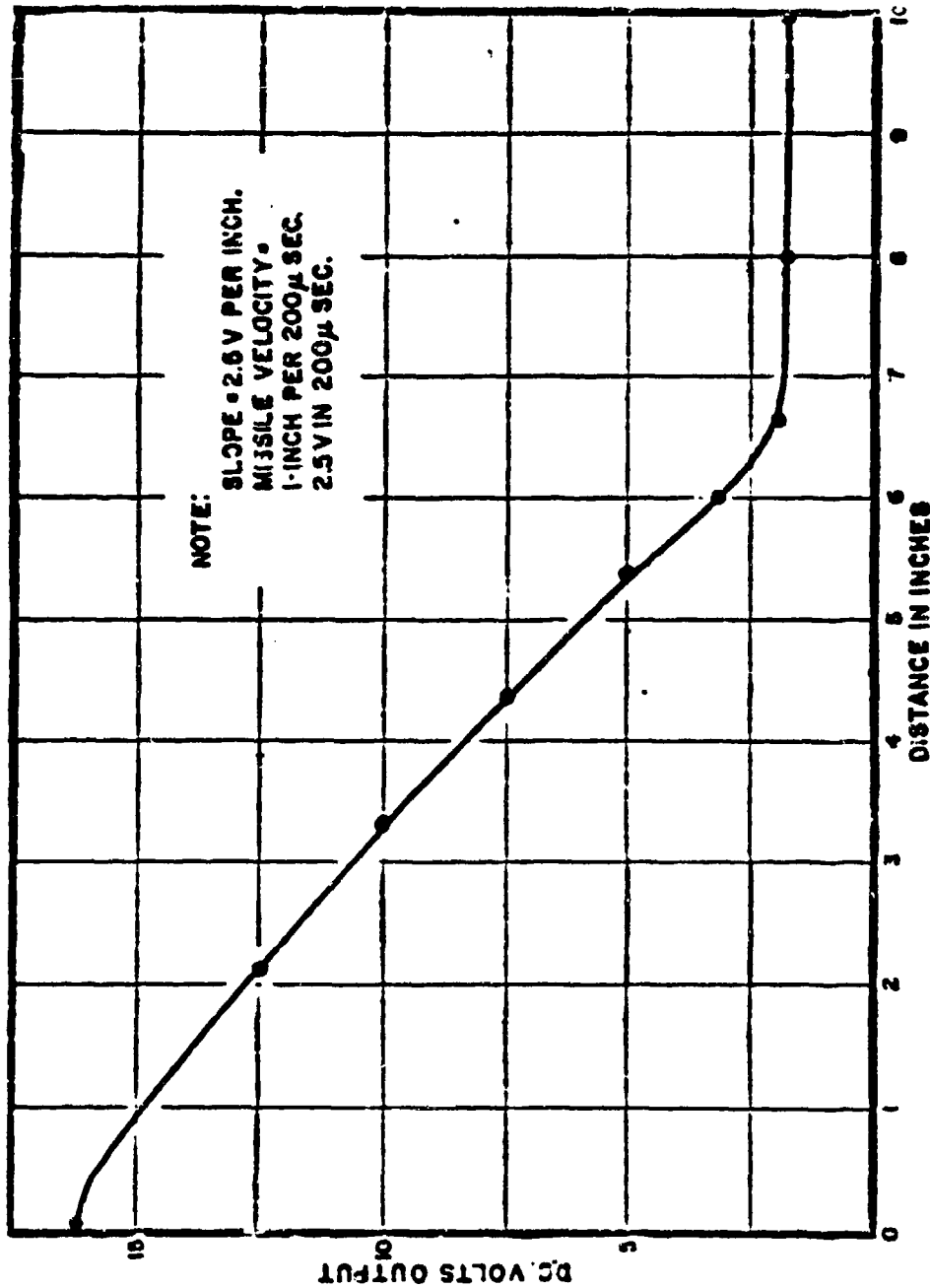


Figure 7. Output voltage vs distance from ground (Amplifier A).

SECRET

CONFIDENTIAL

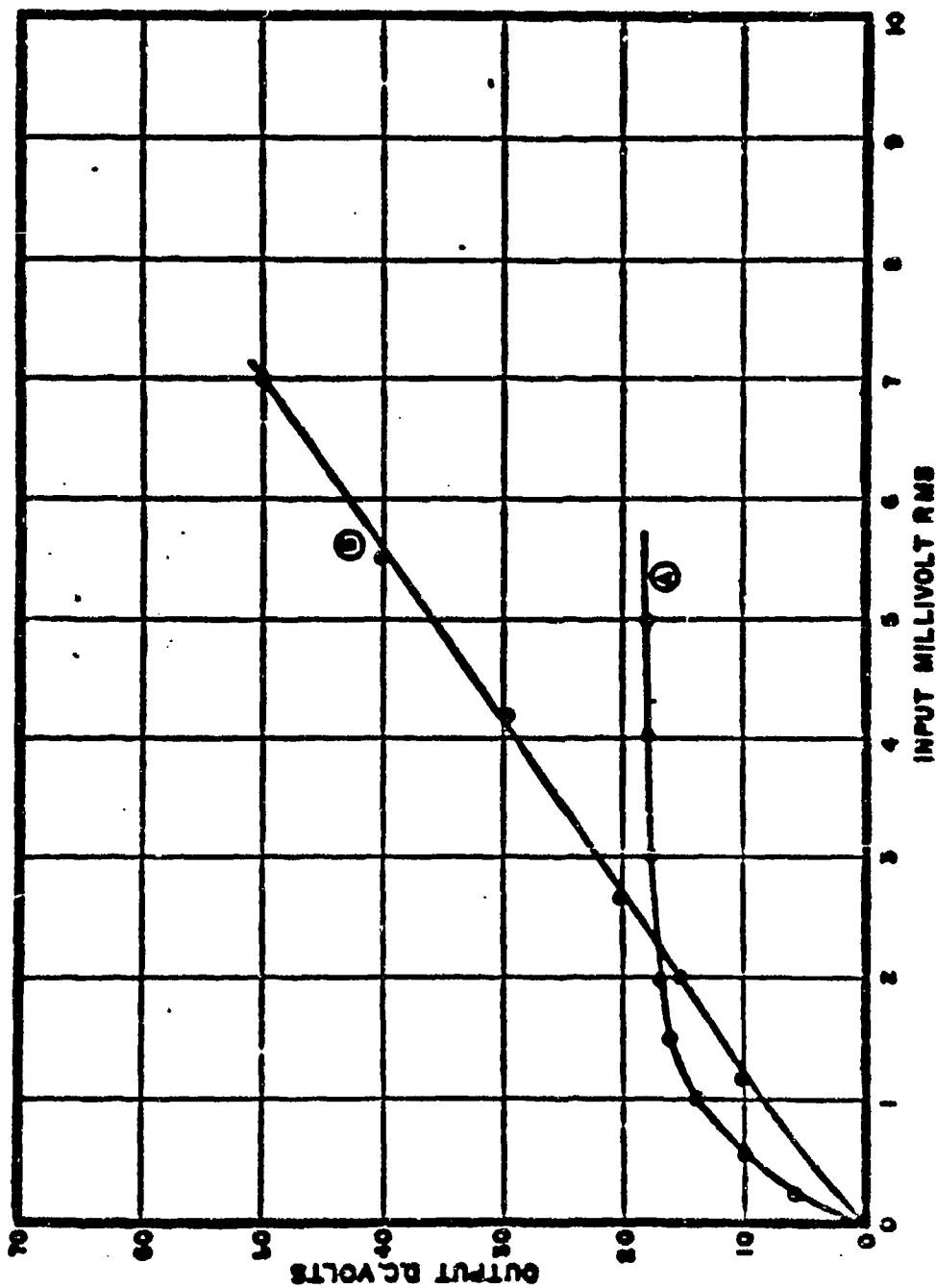


Figure 9. Output voltage vs input voltage (Amplifiers A and B).

CONFIDENTIAL

SECRET

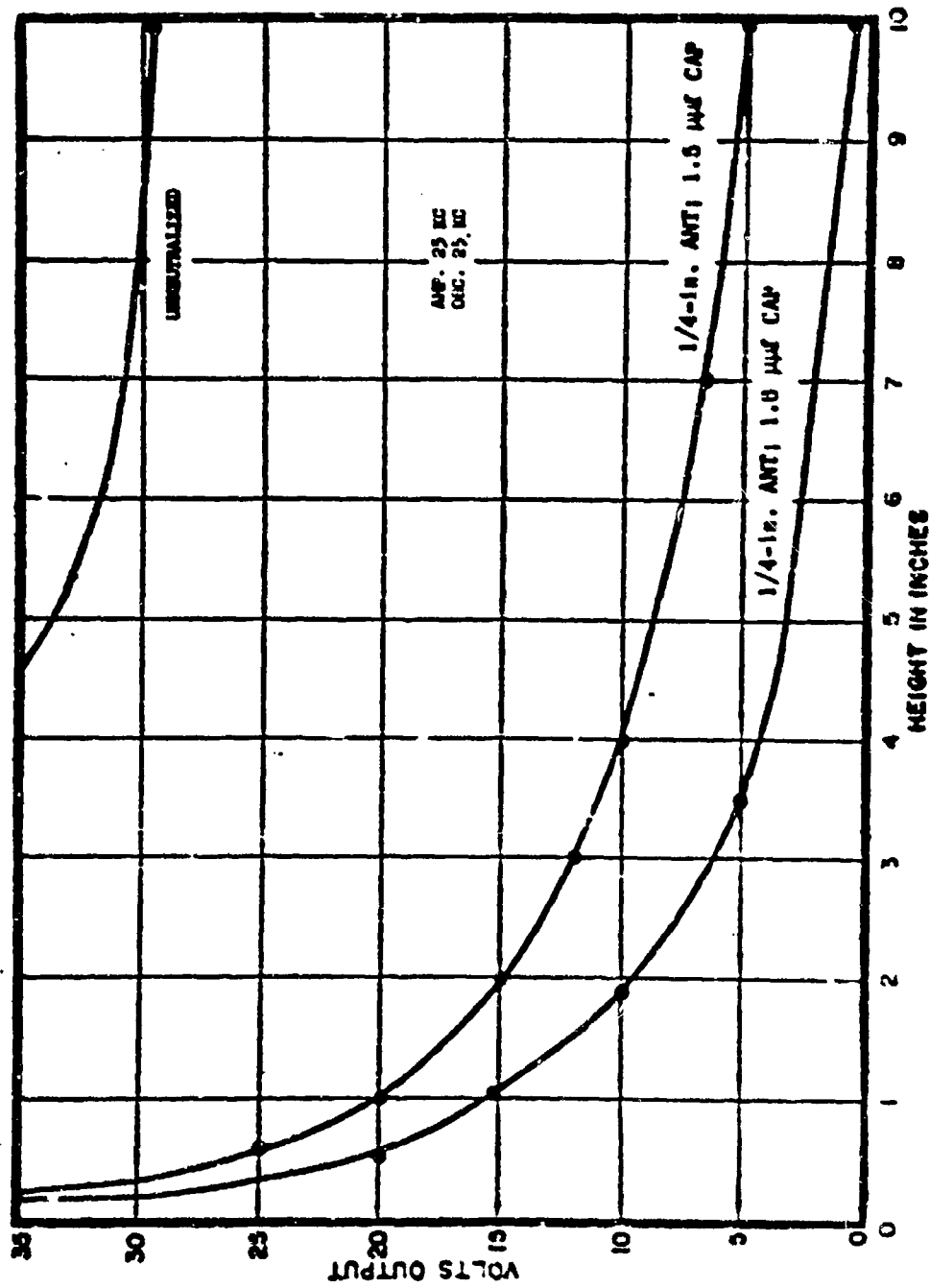


Figure 10. Output voltage vs distance from ground (Amplifier B).

SECRET

SECRET

Since the 6.25 transistor was not sufficient for use, it was decided to build an amplifier around the 6.25 transistor. The manufacturer had shown this transistor to have a very low failure rate at 10 to 15 years. The resulting amplifier circuit is shown in figure 8. Because of difficulty in obtaining enough cores in time for the program, the cores of figure 8 were used only for the oscillator, and commercial vacuum tube pentodes 79 and 80 were used for the amplifier. A typical input curve for the amplifier is shown in figure 9. This amplifier does not saturate at the 4-ray free space signal, whereas, the first amplifier does. The length of the cylindrical core was increased from 1.5 inch to 2.4 inch and lower amplifier gain could be obtained.

Curves of output vs input for the amplifier are shown in figure 10 for two neutralization, and with two different values of neutralization. It is clear that neutralization is not critical and that a fixed capacitor can be used.

After the 6.25 transistor was checked out, several rounds were attempted. Five were completed, but two did not work out after over 100 hours (one in it had an open filament; the other had a short between plate and filaments). One of the three remaining rounds did not have neutralization after a week, but it was considered satisfactory for use. There were the three rounds completed by January 1, 1959.

Comments were given to complete these rounds. These were made up like the seven rounds. However, several of the amplifiers had too low a gain, and some of the amplifiers and oscillators were close enough to each other in frequency. The amplifier gain was increased by changing one of the capacitors as shown in figure 3. The oscillator frequency was returned to the desired value by adding a capacitive load. Amplifiers and oscillators were matched so that the frequency of the oscillator was close to the natural frequency of the amplifier. The 6.25 transistor rounds were used in the first 10 days of the first tests.

SECRET